IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application for

IMPROVED MOLDABLE, NEEDLE-PUNCHED AUTOMOTIVE CARPET

1. Field of the Invention

The present invention relates to better performing carpets for automotive flooring. In particular, the present invention relates to improved durability in carpets for automotive flooring. More particularly, the present invention relates to durable needle-punched carpets capable of being molded to conform to the shape of the automotive floor.

2. Prior Art

Automotive carpeting is made primarily by two methods. In a common method, solution-dyed extruded polyester fiber is "needle-punched." In another common method, a colored extruded bulk continuous filament (BCF) nylon fiber is more thickly "tufted" on a fabric backing material. Tufted automotive carpets typically are more expensive than needle-punched. Alternatively, tufted auto carpets may be made with uncolored nylon and later dyed.

a. Tufted Carpets

The use of molded carpet modules for carpeting motor vehicle interiors is an old and well-established practice. U.S. Patent Nos. 5,474,829 and 5,605,108 recite the teachings of U.S. Patent Nos. 3,953,632 and 4,579,764, which latter patents are concerned with backing materials and molding features forming the modules. Also, recited are U.S. Patent Nos. 4,871,602 and 5,109,784, which patents are directed to floor mats for use in automobiles that have strips in which more pile yarn is tufted into the backing fabric to form an area more resistant to wear.

The '829 and '108 patents themselves are directed, respectively, to a variable density motor vehicle carpet and a method of forming same. The method includes tufting in such a manner that selected areas have pile tufts arranged at lower densities than the selected high density areas, with the areas of high density having a greater resistance to wear that the areas of low density.

U.S. Patent No. 4,016,318 discloses a method of making a moldable automobile mat formed of a tufted carpet having a stiff, heat-moldable thin layer urethane resin layer bonded to the back of the carpet to secure the tufts to the carpet and having a thick layer of a flexible, cross-linked, thermoset, elastomeric urethane resin secured to the stiff thermoplastic urethane resin layer.

b. Needle-Punched Carpets

Needled textile fabrics are normally composed of synthetic organic textile fibers, such as polyester or polypropylene fibers, needled together into a consolidated mat. Such fabrics may also be made of natural organic fibers capable of being formed into a non-woven fabric of substantial properties by the more traditional process, such as felting, and as such, are not usually needled to form a non-woven fabric.

Thus, most needled fabrics, being composed generally of synthetic organic fibers, find a variety of applications where relatively high physical properties are required, e.g. high strengths, with substantially uniform physical properties in both the longitudinal and widthwise direction, and particularly in those applications where economics dictate the use of materials less expensive than tufted fabrics or where the applications require more uniform thickness direction properties than tufted fabrics. Fabrics are generally restricted to synthetic organic fibers, but the application of using polypropylene fiber needled fabrics has

been substantially limited when higher temperatures are involved. Thus, the normal polypropylene fiber needled fabrics suffer from considerable disadvantages in these regards. (U.S. Patent No. 5,547,731 teaches "Needled Carpet and a Process for Producing It.")

The art has attempted to overcome these disadvantages by use of a number of different approaches. Blends using polypropylene were used, but without significant improvement in wear performance.

The European and US car manufacturers have very different standards for the wear performance of flooring carpets. In the US, until a few years ago all the automotive flooring products were tufted and had to meet a performance of from about 2,000 to about 3,000 cycles on the Tabor Abrader test, requiring more expensive tufted carpeting. In Europe, however, the standard is about 300 cycles on the Tabor Abrader test, permitting use of less expensive needle-punched carpeting. The reason for this difference in performance standards is that in Europe most manufacturers sell their vehicles with separate additional floor mats. Because of the mats, they do not need their flooring to perform to a higher standard. In the US, on the other hand, the big three auto manufacturers sell most of their cars without separate floor mats; therefore, they needed a better performing base flooring product. In the last few years, at least Ford and GM have specified one needle-punched product for one of their vehicles. In both cases, they had to lower their standards for the Tabor Abrader test to about 1,000 cycles to "qualify" a needle-punched carpet product. Both companies have expressed their interest in a needle-punched product that would give them better performance. This desire to introduce a needle-punched product into their flooring systems, on a broader basis, comes from a drive to lower costs, with minimum loss of quality.

Needle-punched carpets made of the polypropylene fiber alone typically performs better than needle-punched carpets made solely of polyester in the Tabor Abrader test. However, a needle-punched carpet formed of polypropylene fiber alone is not moldable; whereas a needle-punched carpet formed of polyester fiber alone is moldable. (All flooring systems for US cars are molded.) So, there exists a need in the industry for a less expensive, durable, moldable auto carpet.

SUMMARY OF THE INVENTION

By combining a critical proportion of polypropylene and polyester fibers, a process was developed to produce an improved moldable, needle-punched automotive carpet. The improved carpet comprises a blend of fibers with specific properties that, when used to manufacture the needle-punched auto carpet, exhibits improved the wear *and* produces a moldable carpet, heretofore achieved only with more expensive tufted carpets. In addition to the critical blend of specific fibers, it was discovered that the addition of a binder fiber enhances the wear performance of carpets made from this critical fiber blend. As an optional last process step, it was further discovered that a unique finish material additionally improved the wear performance of carpets made from the blend of fibers disclosed herein.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Known needled-punched carpets typically have a backing of film or latex. After being needled, the tightly integrated fibers are impregnated with a binder, like latex or molten polyester or other like material. This way, the fibers in the top of the carpet are reinforced and anchored fast, so they cannot be pulled out as the carpet is used.

In U.S. Patent No. 4,389,443, a cut pile fabric is taught. The cut pile fabric includes a needled non-woven batt of staple fibers that has an integral carrier member formed by

fusing a face surface of the needled batt. A texturized surface is formed on the batt using a texturized needle loom, which punches through the batt from the one surface (called the back surface) of the batt so that texturized loops project from the carrier member. The non-texturized back surface of the batt typically has a backing applied as by latexing, fusing, or the like, with the texturized loops being tigered by a tigering roll to break, fracture or cut a high percentage of the loops. The tigered pile is typically polished by a polishing roll to remove the crimps in the fibers and to orient the fibers in a direction transverse to the plane of the batt prior to being sheared in a shear. A dense, plush, lightweight cut pile fabric is produced having stability and strength. The patent examples employed polyethylene fibers only, and the resultant stable, strong pile fabric was not molded.

It is understood that the invention moldable, needle-punched automotive carpet with improved wear performance may be prepared by methods generally known in the art. The invention improvement lies in the materials employed, as specified and claimed herein.

Needle-Punch Process

State-of-the-art computerized production lines for the manufacture of needle-punched carpets typically start with the provision of a raw material resin in the form of pellets from rail hopper cars and transferred, for storage until fed into the production line, in silos.

The first step in the production process is extrusion and spinning. (In the case of polyester, the resin material is crystallized and dried before extrusion.) The resin is usually blended uniformly, in molten state, with color pigments and other additives. The molten blend is extruded and flows under pressure through spinnerettes. (The denier and shape of the fiber is determined at this point.)

The next step involves drawing and annealing the fiber. During drawing, individual filaments are mellowed with heat, stretched, and annealed to achieve the elongation characteristics and strength required. In a subsequent step after drawing, the fiber is crimped to a "Z" shape for fiber cohesion, heat set, and cut to the desired length. Cut fibers are baled and, if necessary, are blended in certain proportions with other fibers appropriate for a specific fabric in production.

These bales of prepared fibers can then be opened and broken into clumps of fiber in hoppers designed to achieve a uniform fiber dispersion. The needle-punch operation begins with a carding operation, where fibers in the dispersion are combed by saw-toothed wire cylinders into a uniform web in which the orientation of alignment of individual fibers is closely controlled. Rollers then move the web of aligned fibers through cross-lapping equipment that operates to build up layers of fiber webs to achieve the desired weight and to improve uniformity of properties across the width of the web. Finally, the process gets its name by passing the layed-up (or cross-lapped) web through a needle loom where repetitive penetration by barbed needles binds the web into a tight fabric by mechanical entanglement of the fibers. The finished fabric leaving the needle loom is then taken up on rolls.

The Materials

Polypropylene is a very versatile polymer. It serves double duty, both as a plastic and as a fiber. As a fiber, polypropylene is used to make durable carpeting, such as indoor-outdoor, as well as automobile carpets. It works well for outdoor carpet because it is easy to make colored polypropylene, and because polypropylene doesn't absorb water, like nylon does. These are also reasons it performs well for auto carpets. The polypropylene preferred in the present invention is round and exhibits a denier of from 10 to 25, preferably16-20, and

most preferably 18. The preferred polypropylene also exhibits a tenacity of from 2.2 to 6 g/denier, preferably from 3 to 5 g/denier, and most preferably 4 g/denier.

The polyester preferred for use in the present invention is another versatile fiber. It is used for needle-punched carpets, trunk liners, and auto headliners, among other uses. Preferably, the polyester is also recyclable. The polyester fiber of the invention is round and exhibits D_{tex} value from 10 to 25, preferably 18±1.5, a tenacity value of 2.5-4.6 g/denier, preferably 3.5±1.5 g/denier and an elongation at break of 70%±35%.

The invention wear improvement in a moldable, needle-punched auto carpet is preferably achieved by inclusion of a binder fiber. The binder fiber should exhibit a relatively low softening temperature that may include a polycaprolactone, a polyethylene, and a polyester. The preferred binder fiber for inclusion in the invention is a polyester that is a melt activated thermobonding fiber that exhibits a D_{tex} value from 2 to 16, preferably 4±1.0, and an activation termperature range of 100-185°C, preferably 110-180°C.

The invention wear improvement in a moldable, needle-punched auto carpet is also preferably achieved by inclusion of a lubricant. The preferred lubricant for inclusion in the invention is a non-yellowing yarn lubricant is a homogenous blend of polymers and surfactants that is dispersible in cold and hot water, is nonionic or mildly amphoteric, exhibits a pH from 5.0-7.0 and has a density 6-10 lbs/gal, preferably 7-8 lbs/gal, and most preferably 8.3 lbs/gal.

Fiber loss and wear criteria for acceptability in auto carpet flooring are primarily determined by passing established minimum standards. Specimens tested for fiber loss cannot exceed 10% weight loss. Specimens tested for wear must achieve a satisfactory rating after 1400 taber wear cycles, 600 cycles for fiber loss plus an additional 800 cycles

for wear. The taber wear test involves exposing a carpet specimen to repetitive rotations of the taber abrader. To achieve a rating of satisfactory, there shall be no backing scrim visible for tufted carpets and no complete holes for nonwoven carpets.

Example 1

Fiber loss was measured in auto floor system samples of various compositions of polypropylene and/or polyester fibers. The following data show the least percent weight loss for the improved wear moldable, needle-punched carpet samples.

Data was collected from samples prepared as follows:

All samples tested were prepared in the manner of needle-punched carpet preparation disclosed above. "A" designated samples were prepared of 100% polyester with latex backing. "B" designated samples were prepared of 100% polypropylene with latex backing. "C" and "D" designated samples were prepared of 70:30 polyester/polypropylene with latex backing. "E" and "F" designated samples were prepared of 65% polyester, 28% polypropylene with 7% binder fiber with latex backing. "G" and "H" designated samples were prepared of 65% polyester, 28% polypropylene fused with 7% binder fiber. "J" through "M" designated samples were prepared of 65% polyester, 28% polypropylene fused with 7% binder fiber. "N" and "P" designated samples were prepared of 100% polyester fiber, and represent the current auto carpet product being marketed to at least one major U.S. auto manufacturer. "Q" through "T" designated samples were prepared of 18 denier 65% polyester, 28% polypropylene blends with 7% binder fiber with latex backing.

For the purposes of these examples, the polypropylene fiber used was standard automotive grade fiber manufactured by Drake Extrusion Inc. The polyester fiber employed in the samples containing same was FOSSFIBRE® Solution Dyed PET, available from Foss

Manufacturing Co., Inc. The fiber binder employed in the samples was FOSSFIBRE® TYPE 410 PETG, from Foss Manufacturing Co., Inc. The lubricant employed in the samples for examples was FLUFTONE® APS manufactured by Apollo Chemical Corporation.

Table I

Floor System Samples	1000 cycles	1400 cycles	2000 cycles	2500 cycles
A1	4.90%			
A2	4.71%			
A3	4.75%			
A4	4.75%			
B1	3.07%			
B2	2.96%			
B3	3.12%			
B4	3.09%			
C1	2.72%			
C2	2.50%			
D1		2.57%		
D2		2.83%		
E1	3.02%			
E2	2.77%			
F1		3.03%		
G1	2.92%			
G2	3.26%			
H1		3.44%		
H2		3.54%		
J1	2.02%			
J2	2.20%			
K1		2.38%		
K2		2.64%		
L1			2.48%	
L2			2.32%	
M1				2.23%
N1	3.72%			
N2	4.11%			
P1		3.59%		
P2		3.29%		
Q1	1.63%			
R1		1.63%		
S1			1.29%	
T1				1.95%

Comparisons between samples "A" and "B" show the reduced fiber loss using polypropylene versus polyester fibers. Comparisons between samples "C" and "D" show only a minor increase in fiber loss at 1400 cycles (2.70% ave.) versus 1000 cycles (2.61% ave.). Similarly, comparisons between latex-backed, fiber blended samples "E" and "F" show only a minor increase in fiber loss at 1400 cycles (3.03%) versus 1000 cycles (2.88%). At both 1000 cycles (3.09% ave.) and 1400 cycles (3.49% ave.), fused, fiber blended samples "G" and "H" experienced greater fiber loss than same fiber based "E" and "F." Yet, molded, fiber blended samples "J" through "M" showed significant reductions in fiber loss over earlier fiber-blended samples at 1000 cycles (2.11% ave.), 1400 cycles (2.51% ave.), 2000 cycles (2.4% ave.) and 2500 cycles (2.23%). Current product samples (100% polyester) showed poor fiber loss performance at the lower cycle ranges (3.91% ave. at 1000 cycles and 3.44% ave. at 1400 cycles). Finally, by far the best fiber loss reductions were achieved by the invention fiber blend samples at each cycle count tested.

Thus, Table I shows the improvement (*i.e.*, reduction) in percent fiber loss in the disclosed invention wear improved carpet employing the disclosed and claimed composition of fibers over carpet manufactured employing prior art materials.

Example 2

The tabor abrader test (ASTM D3884-92), as discussed above, indicating standards for pass/fail determinations for floor carpeting were conducted on samples of the same carpet compositions of Example 1. The tabor abrader pass/fail determinations are shown in Table II below.

Table II

Sample	Results	
A1		Fail
A2		Fail
A3		Fail
A4		Fail
B1		Fail
B2		Fail
B3		Fail
B4		Fail
C1	Pass	
C2	Pass	
D1		Fail
D2	Pass	
E1		Fail
E2		Fail
F1		Fail
G1	Pass	
G2	Pass	
H1	Pass	
H2	Pass	
J1	Pass	
J2	Pass	
K1	Pass	
K2	Pass	
L1	Pass	
L2	Pass	
M1		Fail
N1	Pass	
N2	Pass	
P1		Fail
P2		Fail
Q1	Pass	
R1	Pass	
S1	Pass	
T1	Pass	

As might be expected, reduced wear generally corresponded with the fiber loss values as shown in Table I. Thus, improved wear reduction was observed with the invention fiber blend compositions than was observed with the conventional carpet constructions.

It is to be understood that the present invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments, and of being practiced or carried out in various ways within the scope of the claims. Also it is to be understood that the phraseology and terminology employed herein is for the purpose of description and not of limitation.